

Build a crystal filter to solve VHF interference

When adjacent-channel signals as close as 15kHz to the desired frequency interfere with reception, a crystal filter may offer the best solution to combine low insertion loss with high attenuation.

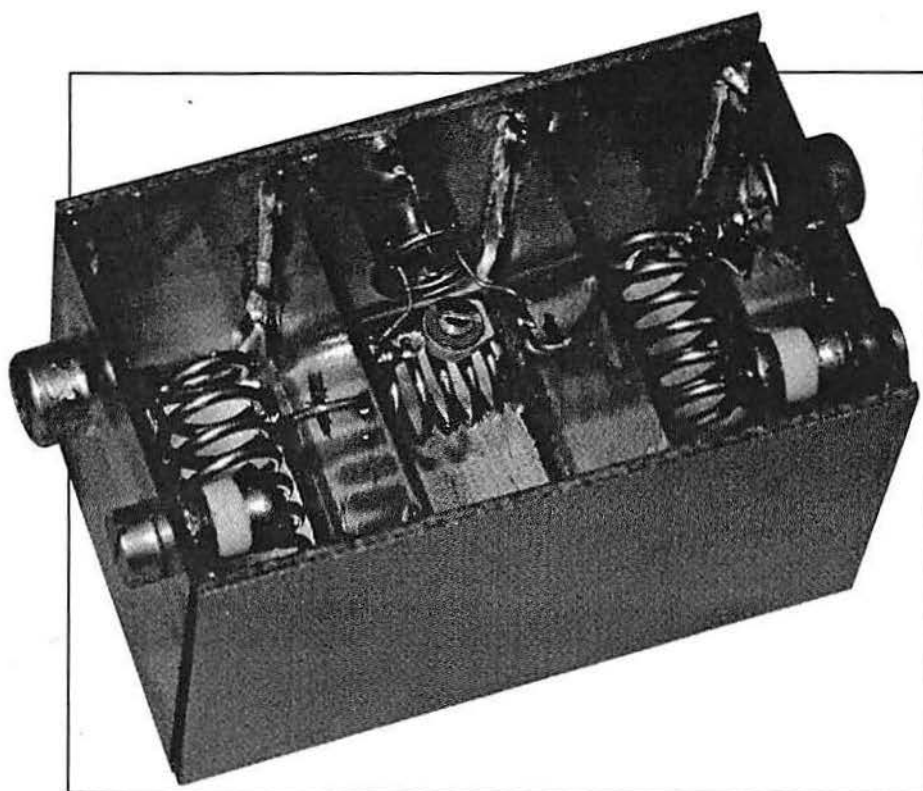
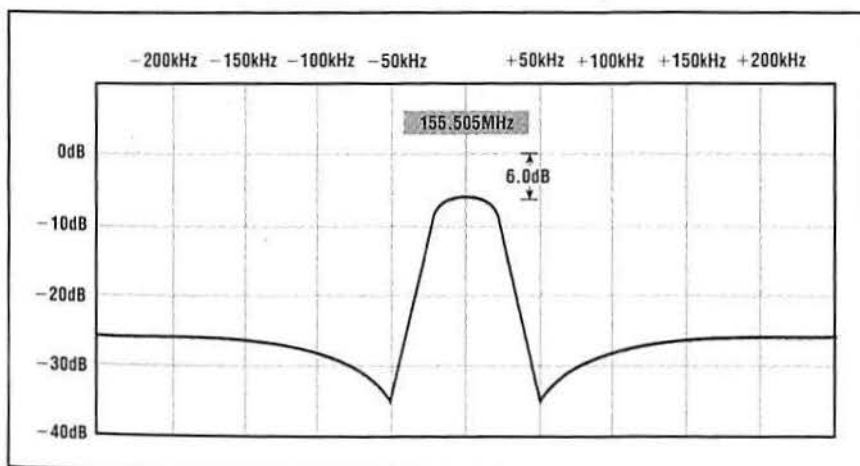


Photo 1. The single-filter, high-pass and low-pass filter of Figure 2 on page 56.



By Patrick E. Buller

One of the best solutions for adjacent-channel VHF highband interference is a crystal filter.

But where do you find one? There are very few crystal filter vendors listed in catalogs and product directories.

A homemade crystal filter can reduce by 25dB a VHF highband only 15kHz from the desired signal with only 1.0dB of insertion loss.

With more and more VHF stations appearing as if from nowhere, adjacent-channel interference has become a problem with no ready or reasonable solution. Large (10-inch) cavities configured as notch filters are inefficient for resolving interference caused by signals less than 100kHz from the desired channel frequency. A device with much higher "Q" is necessary for spacings closer than 100kHz.

High 'Q' solution

Crystals, with "Q" values higher than 70K, are the solution. A crystal filter can be configured either as a high-pass or low-pass notch filter with low insertion loss and, with a second crystal, as a symmetrical band-pass filter.

For many years, Motorola has offered

Figure 1. The Motorola model TLD6340A crystal selectivity curve with an 18.0kHz passband, 6.0dB insertion loss and 40dB maximum attenuation at a spacing of about 120kHz from the center frequency. Attenuation specifications are 13dB, adjacent channel, and 20dB minimum for alternate channels and greater.

Buller is an electronics design engineer for the Washington State Patrol, Bellevue, WA. He is a member of the Radio Club of America, IEEE, NARTE and APCO. He earned an amateur radio license in 1950, a commercial radio license in 1959 and a B.S.E.E. in 1963.

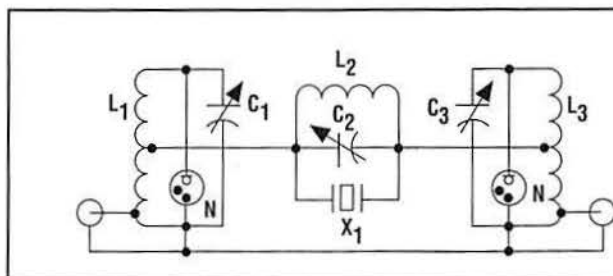


Figure 2A. This schematic diagram represents the best single-crystal, high-pass and low-pass filter based on the Washington State Patrol filter experiments. It uses an AT cut, 5th overtone crystal on 150MHz-160MHz frequencies.

SINGLE-CRYSTAL HIGH-PASS/LOW-PASS NOTCH FILTER

- L_1, L_3 7 turns No. 16 AWG, 5/16" I.D., spaced 7/8", tapped at 3/4 turn input
- Output tapped at 3 1/2 turns from cold end for crystal
- L_2 6 turns No. 18 AWG, 5/16" I.D., spaced 5/16"
- C_1, C_3 10pF variable capacitor, Voltronics AP10SD
- C_2 8pF ceramic trim capacitor
- N NE-2 neon bulb

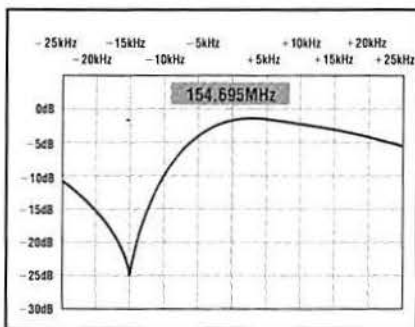


Figure 2B. The response curve of the filter adjusted for high-pass applications.

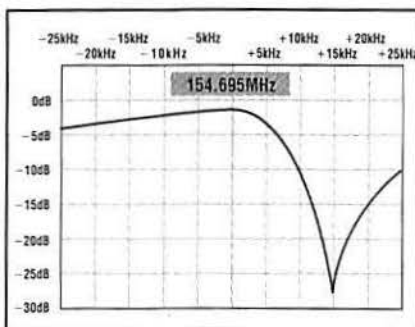


Figure 2C. The response curve of the filter adjusted for low-pass applications.

VHF crystal filters with a passband of 18.0kHz, 6.0dB of insertion loss and 40dB maximum attenuation at a spacing of about 120kHz from the center frequency. Attenuation specifications are 13dB, adjacent channel, and 20dB minimum for alternate channels and greater. Figure 1 on page 54 gives the 1972 specifications.

Crystals in the Motorola device can operate directly across a parallel-tuned circuit; nevertheless, attenuation is about 10dB. This filter has little value as protection from today's adjacent channel interference.

The Product

The SRL-590 series of antennas are fiberglass enclosed collinear omnidirectional antennas, designed for the broadband PCS/PCN market of 1.7-2.5 GHz band.

This series of antennas features the uniquely designed Sinclair binary feed design harness developed for low intermod and precise pattern control.

All antennas cover a 200 MHz bandwidth and are heavy duty (H.D.) rated for wind and ice conditions.

Sinclair proudly brings to market a range of innovative products.

- High quality products which reflect leading technologies.
- Rugged products meeting specific needs.
- Off-the-shelf, or tailored to customer specifications.
- Products which enjoy the support of industrial, military and individual customers globally.

SINCLAIR

Sinclair Technologies Inc.

85 Mary Street, Aurora, Ontario, Canada L4G 6X5 Tel: (800) 263-3275 Fax: (905) 727-0861
55 Oriskany Drive, Tonawanda, New York 14150, U.S.A. Tel: (800) 288-2763 Fax: (716) 874-4007
Sinclair Technologies Ltd., William James House, Cowley Road, Cambridge, CB4-4WX, U.K.
Tel: +44 (0) 1223 42 03 03 Fax: +44 (0) 1223 42 06 06

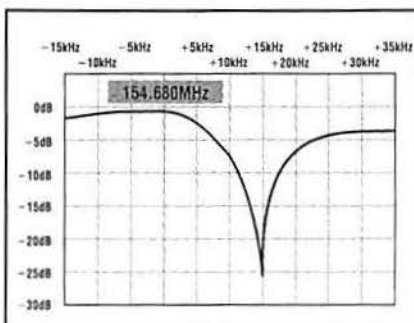
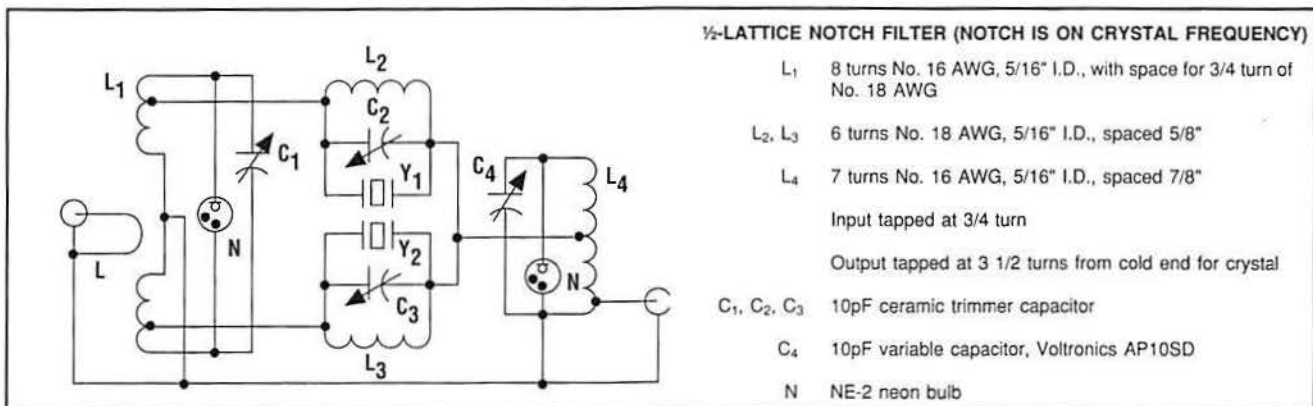


Figure 3B. The response curve adjusted for the high-attenuation, low-pass band-reject mode.

Figure 3A. The schematic diagram represents a half-lattice filter where the notch frequency is that of the two crystals. For greater bandwidth at the notch, one crystal should differ from the other by the required separation, perhaps 5kHz. The distinct advantage of this method is the quantity of notch attenuation obtainable—nearly 65dB with 2.0dB insertion loss, as shown in Figure 3B. Parallel resonant circuits L_2 and L_3 shift the crystal's resonant properties for the greatest attenuation.

Piezo Crystal, a vendor that was interested in cooperating in the Washington State Patrol filter experiments, can supply AT cut, 5th overtone crystals on 150MHz–160MHz frequencies. Many circuits were tried during the research and development stage that resulted in a more thorough understanding of crystal behavior in this ap-

plication. The best single-crystal, high-pass and low-pass filter is shown in Photo 1 on page 54 and Figure 2 on page 56. High-pass and low-pass characteristics are shown in Figures 2B and 2C.

Simplified design

The advantage of this design is that the

What *Really* Turns You On?

The "Smart Vox", used with any of our audio accessories, will recognize your voice in varying noise - from quiet to deafening - and will consistently turn on your radio . . . but only when you talk. No loss of words at the start of a message, no false keying, no adjustments, no modifications.

How's that for a turn on?

For completely HANDS-FREE, RELIABLE RADIO COMMUNICATIONS, get turned on by our "Smart Vox".



Contact:

Setcom

CORPORATION

1400 North Shoreline Blvd.
Mountain View, CA 94043
(415) 965-8020



Circle (49) on Fast Fact Card

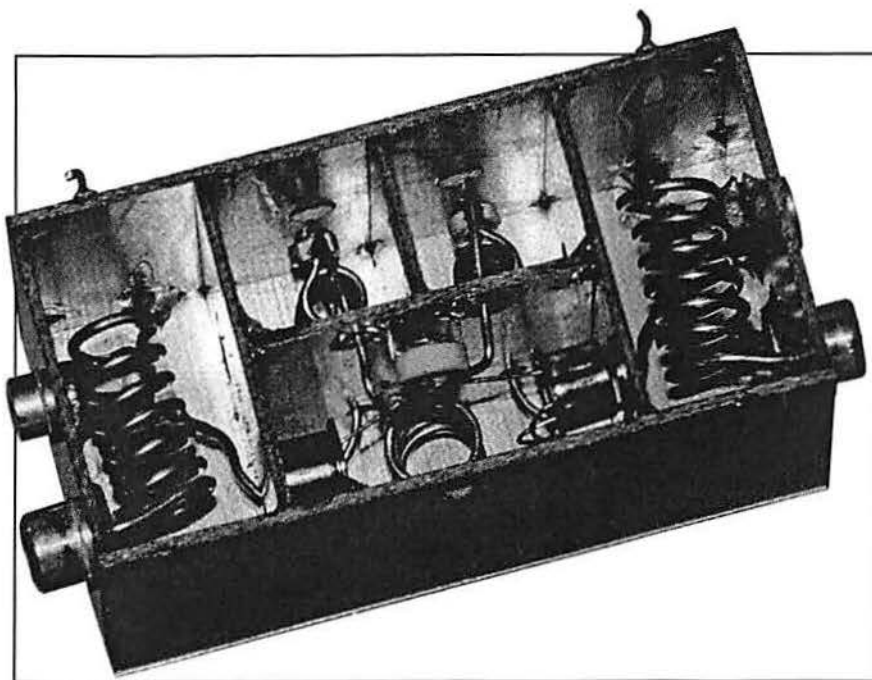


Photo 2. This picture shows the band-pass filter of Figure 4.

crystal determines the pass frequency, and its shunt element determines the notch frequency. This design resembles tunable cavities, used for duplexing and combining

where cavity tuning determines the pass frequency, and link tuning sets the reject frequency. This approach to crystal filter tuning simplifies the design. Choose the

crystal for your pass channel frequency and tune to the interference.

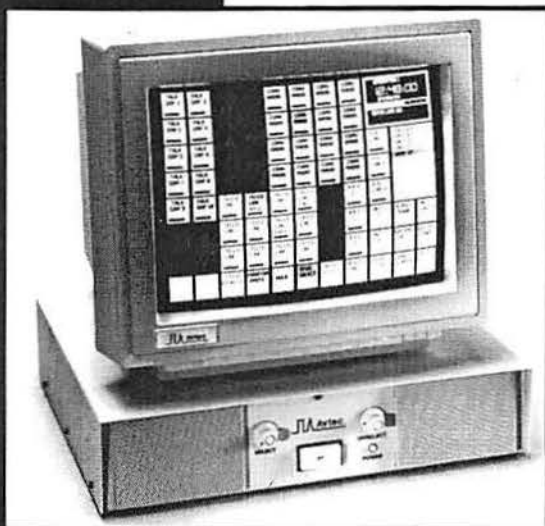
Input and output coils, L1 and L3 in Figure 2, match the 50V input and output line impedance to the Piezo crystal impedance, minimize the insertion loss and provide a small phase shift to compensate for slight crystal differences.

Tuning L2 from high-pass to low-pass, or the reverse, without tuning L1 and L3 does not yield low insertion loss. Changing the "tank Q" to fewer turns and increasing the capacity results in less flexibility in adjusting from high-pass to low-pass applications. All 20 crystals used for research and development matched the same impedance tap on the tuned coils.

Half-lattice filter

Figure 3 on page 58 is the schematic of a half-lattice filter, where the notch frequency is that of the two crystals. For greater bandwidth at the notch, one crystal should differ from the other by the required separation, perhaps 5kHz. The distinct advantage of this method is the quantity of notch attenuation obtainable—nearly 65dB with 2.0dB insertion loss, as shown in Figure 3A. Parallel resonant circuits L2 and L3 shift the crystal's resonant properties

DSPatch—THE WORLD'S MOST ADVANCED DIGITAL SWITCH FOR VOICE COMMUNICATIONS



architecture ensures instant responses, even in large systems. DSPatch may be configured to support from 32 to 1,024 external lines or operator workstations.

Utilities, airlines, railroads, public-safety, military and other government agencies worldwide have come to rely on Avtec for advanced, high-capacity console solutions for integrated radio/telephone systems. DSPatch is a color touchscreen console system that employs Digital Signal Processors (DSP's) at every line and workstation. Its distributed

FEATURES INCLUDE:

- ◆ User configurable screens
- ◆ Conventional or trunked radio
- ◆ ANI with call queue
- ◆ Multi-format paging
- ◆ Simultaneous conferences
- ◆ Many more

DSPatch32, a 32-port system, is available for smaller applications.

Call, fax or write for additional information or a budgetary proposal.



4335 Augusta Highway
Gilbert, SC 29054 USA
Phone: (803) 892-2181
FAX: (803) 892-3715

Figure 4A. The schematic diagram of a band-pass crystal filter with two crystals on the same frequency. Each crystal shunt element is tuned to the first adjacent channel above and the first adjacent channel below. The advantage of this circuit is that it can be tuned as a band-pass filter (Figure 4B) or as a band-reject filter (Figure 4C) with higher attenuation than what can be obtained with the single-crystal method.

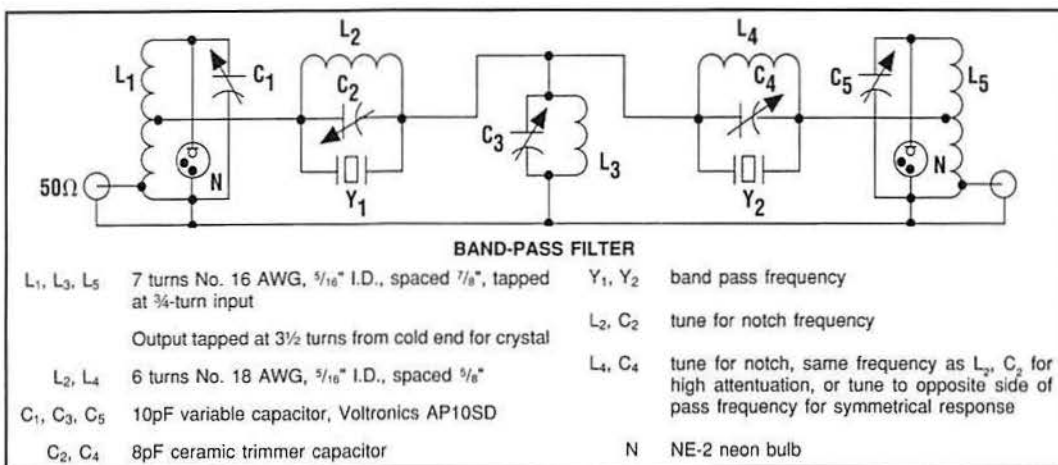


Figure 4B. Response curve of the two-crystal filter adjusted for band-pass applications.

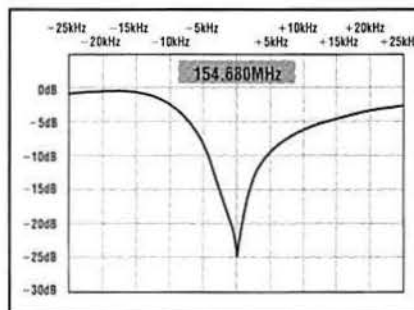
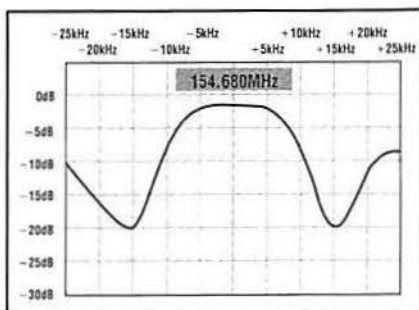


Figure 4C. Response curve of the two-crystal filter adjusted for a single-frequency notch.

GAMBER-JOHNSON

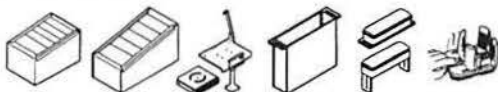
MCS-100 SERIES

The Gamber-Johnson MCS-100 Series is an economical alternative to consoles for mounting voice and data communications equipment in your Caprice or Crown Victoria.

Our base is one piece, made of 3/16" electrostatically powdercoated steel. For safety, all edges are milled and corners rounded. Our design allows installation in minutes without drilling or modifying the vehicle. Our radio brackets are universal and simple to install and adjust. The 22 1/2" mounting surface gives you room for up to six sets of radio brackets, or a combination of brackets and a Gamber-Johnson MCS Series MDT or Laptop/Notebook mount. We even offer an adjustable armrest to assure an ergonomically correct work station.

The simplicity and strength of our design provides a margin of safety unsurpassed in the industry, and ease of installation which saves you time and money. Of course, the MCS-100 system is air bag friendly when properly installed, and, if desired, may be upgraded to an enclosed console protecting your initial investment years into the future.

Partial
accessory
sampling



MCS-100 SERIES



For information now

CALL 1-800-GJ-MOUNT 1-800-456-6868
FAX 1-800-WE-HELPP 1-800-934-3577

GAMBER-JOHNSON
Service & Solutions™
801 Francis Street, Stevens Point, Wisconsin 54481

for the greatest attenuation.

Photo 2 on page 60 and Figure 4 on page 62 represent a band-pass crystal filter with two crystals on the same frequency. Each crystal shunt element is tuned to the first adjacent channel above and the first adjacent channel below. The advantage of this circuit is that it can be tuned as a band-pass (Figure 4B) or as a band-reject filter with higher attenuation than the single-crystal method.

Interaction in tuned circuits L2 and L4 prevents uniform attenuation curves in the reject mode. (See Figure 4C.) Its attenuation is better than two filters in series (as shown in Figure 2) by about 0.75dB.

Filter characteristics

With a spectrum analyzer and a tracking generator, it is possible to display the filter's characteristics. Notice in Figure 4A that there are "spurs" (spurious responses)

above the crystal frequency at a lower level. These spurs have no effect upon the receiver's "on-frequency" performance.

Field tests with a 25dB notch filter, like the one in Figure 2, reduced a 15kHz adjacent signal from 300mV to 15mV, including the filter's 0.8dB insertion loss. The tests also proved that it interfaced in series with 10-inch cavities without additional loss.

The design of the Figure 2 filter was optimized for close-channel problems, although it can be tuned from the crystal frequency to approximately 100kHz on the low-frequency side and nearly 65kHz on the high-frequency side. For interference control at frequencies beyond 150kHz from the center frequency, there are other, more efficient, circuit arrangements.

Making adjustments

A spectrum analyzer with a tracking generator (or with signal generator and a tracking source) makes adjustments simple. If you are without these instruments, try this approach: Align input and output coils L1 and L2 of the filter, as in Figure 2, for maximum output signal at the received (crystal) frequency. Apply a signal at the desired notch frequency, and tune L3 for maximum attenuation at the output. Always have a valid 50V resistive load on each side of the filter for optimum performance.

Manufacturing 5th overtone crystals at this frequency is rather difficult. The first devices that were tried had little attenuation. At Piezo Crystal, it was theorized that the leads attached directly to the crystal element were too large, restricting performance.

The second-generation devices proved the theory. The 7th overtone has less notch attenuation than the 5th and 3rd overtones.

The enclosure for the crystal filters is made from double-sided printed circuit board stock soldered within each compartment. RCA phono jacks are used for in/out connections. Coils for the single-crystal filter shown in Figure 2 were wound on a common round pencil with a $\frac{5}{16}$ -inch diameter.

These filter ideas can be further developed to suit other needs. Someone probably will substitute toroids for the inductors, or perhaps slug-tuned coils. Use what you have.



STI-CO's new 800 Series (XXX-S-800) cowl-mount disguised antennas cover 60 MHz minimum within the 806-866 MHz cellular and trunking frequency range, and are exact AM/FM antenna replacements for select Ford, Chrysler and GM body styles.

For additional information (or to order) try our new 800 fax number: 1-800-685-1122!

Join the 800 Club with . . .

The
DISGUISE GUYS



11 COBHAM DR. ORCHARD PARK, NY 14127 (716) 662-2680 FAX 1-800-685-1122

Visit us at IWCE, Booth #7061

Circle (55) on Fast Fact Card